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corresponds to SE 9903541-2

UNITED STATES PATENT APPLICATION

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FOR

POSITION DETERMINATION II

Field of the Invention

The present invention relates to a product having a surface which is provided with a coding pattern comprising symbols which have at least two different values. The invention also relates to a method of creating a position-coding pattern, a device for position determination, software for position determination, and use of a position-coding pattern.

Background of the Invention

In many situations it is desirable to be able to determine an absolute position on a surface, for example in connection with the digitization of drawings or when one wishes to create an electronic version of handwritten information.

US 5,852,434 describes a device for the determination of an absolute position. The device comprises a writing surface provided with a position-coding pattern by means of which it is possible to determine X- and Y-coordinates, a detector capable of detecting the position-coding pattern, and a processor capable of determining the position of the detector in relation to the writing surface on the basis of the detected position-coding pattern. The device renders it possible for a user to enter handwritten and hand-drawn information in a com-

puter while at the same time the information is being written/drawn on the writing surface.

Three examples of position coding are provided in US 5,852,434. The first example is symbols, each of which is made up of three concentric circles. The outermost circle represents the X-coordinate and the middle circle represents the Y-coordinate. Furthermore, the two outermost circles are divided into 16 parts, which depending upon whether they are filled in or not indicate different numbers. This means that each pair of coordinates X, Y is coded with a complex symbol with a specific appearance.

In the second example, the coordinates are indicated in each point on the writing surface with the aid of a bar code, a bar code for the X-coordinate being indicated above a bar code for the Y-coordinate.

As a third example, it is stated that a checkerboard pattern can be used for coding the X- and Y-coordinates. However, no explanation is given of how the checkerboard pattern is structured or how it can be translated into coordinates.

One problem associated with the known pattern is that it is made up of complex symbols. The smaller the symbols are the more difficult it is to produce the patterned writing surface and the greater the risk of incor-

rect position determination. But the larger the symbols, the poorer the position resolution.

A further problem is that the processor's processing of the detected position-coding pattern becomes fairly complicated because of the fact that the symbols that must be interpreted are complex.

Yet another problem is that the detector must be designed so that it can record four symbols simultaneously so that it will definitely record at least one symbol in its entirety, which is necessary in order to carry out the position determination.

In Applicant's Swedish Patent Application SE 9901954-9, which was filed on 28 May 1999 and which was not publicly available at the filing of the present application and thus does not constitute prior art, among other things a position-coding pattern is disclosed, which to a great extent obviates the above-mentioned problems.

Summary of the Invention

An object of the present invention is to completely or partly obviate the above problems of prior art.

This object is achieved by a product according to claims 1 and 14, a method according to claim 17, software according to claims 18 and 21, a device according

to claims 23 and 24, and use according to claim 27. Preferred embodiments are defined in the subclaims.

More specifically, the invention relates to a product having a surface which is provided with a coding pattern which comprises symbols having at least two different values. The invention is characterized in that each symbol comprises a raster point and at least one marking, that the raster point is included in a raster extending across the surface, and that the value of each symbol is indicated by the position of said marking in relation to a raster point.

In prior-art, each position is coded with a complex symbol which requires recognition of many different elements and which thus is susceptible to interference. According to the invention, use is instead made of a symbol, whose value is indicated by the position of a marking in relation to a raster point. Consequently there is one type of symbol for each value. This means that a device which is to carry out the position determination need only be able to detect the presence of a marking and it need not be able to differ between different elements, such as the various bars in a bar code, to be able to determine the position. As a result, the detection will be easier and less susceptible to interference.

The design of the inventive symbol further means that a surface provided with a coding pattern according to the invention will be more esthetically attractive.

Furthermore, a distance between the markings which is great in relation to the information density is allowed, which makes the coding less sensitive to motion blur.

In the position-coding pattern in the above-mentioned SE 9901954-9, use is made of points of different size to graphically represent the position coding. The symbols according to the present invention can advantageously be used instead of the points in the position-coding pattern.

The appearance of the markings may vary, but in a preferred embodiment, essentially all markings are identical, which makes the coding pattern easier to detect and easier to apply to a surface.

The symbols described above can be used to code any type of information, but is advantageously used to code positions. In prior art, each position is coded, as mentioned above, with a single symbol which therefore must be fairly complex. According to the invention, each position can instead be coded with a plurality of symbols. Thus, each individual symbol can be made less complex and thus easier to detect in a more reliable manner.

In prior art, each position is coded with a symbol which is "isolated" from the symbols of the surrounding positions. The position resolution is thus limited by the surface occupied by the symbol of a position. The position-coding pattern according to the invention can be composed correspondingly, each position being coded by an "isolated" group of symbols. In a preferred embodiment, however, each symbol contributes to the coding of more than one position. In this way, a "floating" transition between different positions is obtained. In other words, each position is coded partly by the same symbols as the adjoining positions. The floating coding is advantageous since it makes it possible to increase the position resolution. Moreover, it is possible to reduce the relationship between on the one hand the number of symbols which a position-determining device must record to enable safe position determination and, on the other hand, the number of symbols which code a position.

In a preferred embodiment, each symbol contributes to the coding of both a first and a second position coordinate. Thus, different symbols for the different coordinates are not necessary, which makes the position code simpler and the position resolution better. The coordinate system can suitably be cartesian, but also other types of coordinate systems are feasible.

Further, the value of each symbol can advantageously be translatable into at least a first digit which is used for coding of the first coordinate and at least a second digit which is used for coding the second coordinate, the symbols in the position-coding pattern together representing a first position code for the first coordinate and a second position code for the second coordinate. The two coordinates can then be coded independently of each other, which makes the coding easier when the coding is "floating". Preferably, the value of the symbol is represented in a binary manner, a first bit being used for the coding of a first coordinate and a second bit for the coding of a second coordinate.

The position-coding pattern is advantageously based on a first cyclic, preferably binary, number series having the characteristic that no sequence with a first predetermined number of digits appears more than once in the number series. By the position-coding pattern being made up in this manner, it will contain inherent information about the positions so that the coordinates can be calculated according to predetermined rules. This is advantageous since it means that the decoding of the position-coding pattern can be implemented in an efficient manner in, for instance, software. Besides, it will be much easier to produce the position-coding pattern in this way

compared with the case where one would randomly try to generate an unambiguous position-coding pattern of a floating type.

In an advantageous embodiment, the product may comprise a plurality of writing surfaces, each comprising the position-coding pattern. For example, the product may consist of a notepad with a plurality of sheets. The position-coding patterns then differ for the various writing surfaces by the sequence in the cyclic number series with which a predetermined column or row begins. The "same" pattern can thus be used for a plurality of writing surfaces which can be separated or integrated with each other by letting, for instance, the first column begin in different positions in the number series.

The position-coding pattern can be accomplished with any parameter whatever that can be used to produce symbols of the above-mentioned type which can be detected by a detector. The parameter can be electric or chemical or of some other type. However, the position-coding pattern is preferably optically readable, which makes it easier to apply to the surface. The pattern should thus be capable of reflecting the light, but the light need not be in the visible field.

The raster and/or the raster points can be implemented on the surface. In a preferred embodiment, how-

ever, the raster and the raster points are virtual. Thus the raster is not marked on the surface at all, but just constitutes an imaginary raster which forms the base of the coding, but which can be located on the basis of the positions of the markings.

The above described idea of translating the value of a symbol into a first digit for coding the first coordinate and a second digit in the value of each symbol for coding the second coordinate can, of course, be used independently of the exact design of the symbols. Therefore, according to a second aspect of the invention, this concerns a product having a surface which is provided with a position-coding pattern which codes a plurality of positions on the surface and which comprises a plurality of symbols, each symbol having at least four different values. The product is characterized in that each position on the surface is coded with a plurality of symbols and the value of each symbol is translatable into at least a first digit which is used for coding a first coordinate and at least a second digit which is used for coding a second coordinate, the symbols in the position-coding pattern together representing a first position code for the first coordinate and a second position code for the second coordinate.

The advantages of such coding have been described above. It can advantageously be used to implement a floating coding, for instance for implementing a floating coding according to SE 9901954-9. Of course, that stated above for the product having a coding pattern with markings and raster points relates in applicable parts also to the product according to the second aspect of the invention.

The products described above can be any products whatever that have a surface with a coding pattern. They can be used for a large number of applications. For instance, they can be used to continuously record the position of a pen that is being passed over the writing surface. They can also be used to determine the position of a tool, an instrument or the like. Further they can be used as a mouse pad. A person skilled in the art can think of many other applications.

According to a third aspect of the invention, it relates to a method of creating a position-coding pattern, which method is designed for coding a plurality of positions on a surface, comprising the steps of generating a first cyclic number series having the characteristic that no sequence with a first predetermined number of digits appear more than once in the number series; coding a first coordinate by repeating the first cyclic number

series in columns across the surface, different columns beginning in different positions in the number series; generating a second cyclic number series having the characteristic that no sequence with a first predetermined number of digits appears more than once in the number series; and coding a second coordinate by repeating the second cyclic number series in rows across the surface.

A great advantage of this method is that an unambiguous "floating" position-coding pattern can be implemented without a great amount of redundancy.

The first and the second number series can, but need not, be identical.

According to a fourth aspect of the invention, it relates to a computer program which is stored on a storage medium which can be read by a computer and which comprises instructions for making the computer decode the position-coding pattern on a product according to any one of claims 1-16.

According to a fifth aspect of the invention, it relates to a computer program for determining the position of a partial surface on a surface which is provided with a position-coding pattern comprising a plurality of symbols, on the basis of an image of the partial surface, said computer program being stored on a computer-readable storage medium which comprises instructions for making

the computer locate a predetermined plurality of symbols in the image, determine the value of each of said predetermined plurality of symbols, separate the position-coding pattern in the image in a first position code for a first coordinate and a second position code for a second coordinate by translating the value of each symbol into at least a first digit for the first position code and at least a second digit for the second position code; and calculate the first coordinate by means of the first position code and the second coordinate by means of the second position code.

The computer programs can be used together with prior-art position determining devices. They can be installed in a separate computer, to which images of the position-coding pattern are transferred, or in the actual device which records the position-coding pattern.

According to a sixth aspect of the invention, it relates to a device for position determination, comprising a sensor for producing an image of a partial surface on a surface and image processing means, which are adapted to decode a position-coding pattern on a product as claimed in any one of claims 1-16, said surface being a surface on the product, which surface is provided with the position-coding pattern.

According to a seventh aspect of the invention, it relates to a device for position determination, comprising a sensor for producing an image of one partial surface of a plurality of partial surfaces on a surface which is provided with a position-coding pattern, and image processing means which are adapted to locate a predetermined plurality of symbols in the image, determine the value of each of said predetermined plurality of symbols, separate the position-coding pattern in the image in a first position code for a first coordinate for the partial surface and a second position code for a second coordinate for the partial surface by translating the value of each symbol into at least a first digit which is used for the first position code and at least a second digit which is used for the second position code, and calculate the first coordinate by means of the first position code and the second coordinate by means of the second position code.

The advantages of the invention are evident from the above discussion of the position-coding pattern.

By the image processing means of the device being adapted to determine the position in a "rule-based" manner, the device does not require a great deal of memory capacity, which is an advantage in respect of the manu-

facturing cost of the device and the possibility of producing a stand-alone unit.

Advantageously, the image processing means comprise a suitably programmed processor.

The device can be implemented as a stand-alone unit. Alternatively, the sensor can be located in a first casing, while the image-processing means are located in another casing, for example a personal computer to which the images recorded by the sensor are transferred.

According to yet another aspect of the invention, it relates to use of a position-coding pattern, which position-coding pattern is based on a first cyclic number series having the characteristic that no sequence with a first predetermined number of digits appears more than once in the number series; the first cyclic number series being repeated in columns across the writing surface, different columns beginning in different positions in the number series, and on a second cyclic number series having the characteristic that no sequence with a second predetermined number of digits appears more than once in the number series; the second cyclic number series being repeated in rows across the writing surface, different rows beginning in different positions in the number series.

Such use could, for example, consist of storing the pattern electronically.

Brief Description of the Drawings

An embodiment of the present invention will be described in more detail below with reference to the accompanying drawings, in which

Fig. 1 schematically shows an embodiment of a product provided with a position-coding pattern;

Fig. 2 schematically shows how the symbols can be designed in an embodiment of the invention;

Fig. 3 is a schematic view of an example of 4x4 symbols that are used to code a position; and

Fig. 4 is a schematic view of a device which can be used for position determination.

Description of a Preferred Embodiment

Fig. 1 shows a part of a product in the form of a sheet of paper 1, which on its surface 2 is provided with an optically readable position-coding pattern 3 enabling position determination. The position-coding pattern consists of symbols 4 which are systematically arranged across the surface 2, so as to make its appearance "patterned". The sheet has an x-coordinate axis and a y-coordinate axis. In this case, position determination can be carried out on the entire surface of the product. In other cases, the surface allowing position determination

may consist of a smaller part of the product. For example, the sheet of paper can be used to produce an electronic representation of information which is being written or drawn on the surface. The electronic representation can be produced by continuously determining, while writing on the surface with a pen, the position of the pen on the sheet by reading the position-coding pattern.

The position-coding pattern comprises a virtual raster, which thus neither is visible to the human eye nor can be detected directly by a device which is to determine positions on the surface, and a plurality of symbols 4, which each are capable of assuming one of four values "1"-"4" as will be described below. It should here be emphasized that, for the sake of clarity, the position-coding pattern in Fig. 1 has been enlarged to a considerable extent. Moreover, the position-coding pattern is shown only on part of the sheet.

The position-coding pattern is arranged in such manner that the position of a partial surface on the writing surface is coded by the symbols on this partial surface. A first and a second partial surface 5a, 5b are indicated by dashed lines in Fig. 1. That part of the position-coding pattern (in this case 3x3 symbols) which is to be found on the first partial surface 5a codes a first position, and that part of the position-coding pattern which

is to be found on the second partial surface 5b codes a second position. Thus the position-coding pattern is partially shared by the adjoining first and second positions. Such a position-coding pattern is in this application referred to as "floating".

Figs 2a-d show an embodiment of a symbol which can be used in the position-coding pattern according to the invention. The symbol comprises a virtual raster point 6 which is represented by the intersection between the raster lines, and a marking 7 which has the form of a dot. The value of the symbol depends on where the marking is located. In the example in Fig. 2, there are four possible positions, one on each of the raster lines extending from the raster points. The displacement from the raster point is equal to all values. In the following, the symbol in Fig. 2a has the value 1, in Fig. 2b the value 2, in Fig. 2c the value 3 and in Fig. 2d the value 4. Expressed in other words, there are four different types of symbols.

Each symbol can thus represent four values "1-4". This means that the position-coding pattern can be divided into a first position code for the x-coordinate, and a second position code for the y-coordinate. The division is effected as follows:

Symbol value	x-code	y-code
1	1	1
2	0	1
3	1	0
4	0	0

Thus, the value of each symbol is translated into a first digit, in this case bit, for the x-code and a second digit, in this case bit, for the y-code. In this manner, two completely independent bit patterns are obtained. The patterns can be combined to a common pattern, which is coded graphically by means of a plurality of symbols according to Fig. 2.

Each position is coded by means of a plurality of symbols. In this example, use is made of 4x4 symbols to code a position in two dimensions, i.e. an x-coordinate and a y-coordinate.

The position code is made up by means of a number series of ones and zeros which have the characteristic that no sequence of four bits appears more than once in the series. The number series is cyclic, which means that the characteristic also applies when one connects the end of the series to the beginning of the series. Thus a four-bit sequence always has an unambiguously determined position in the number series.

The series can maximally be 16 bits long if it is to have the above-described characteristic for sequences of four bits. In this example, use is, however, made of a series having a length of seven bits only as follows:

"0 0 0 1 0 1 0".

This series contains seven unique sequences of four bits which code a position in the series as follows:

Position in the series	Sequence
0	0001
1	0010
2	0101
3	1010
4	0100
5	1000
6	0000

For coding the x-coordinate, the number series is written sequentially in columns across the entire surface that is to be coded. The coding is based on the difference or position displacement between numbers in adjoining columns. The size of the difference is determined by the position (i.e. with which sequence) in the number series, in which one lets the column begin. More specifically, if one takes the difference modulo seven

between on the one hand a number which is coded by a four-bit sequence in a first column and which thus can have the value (position) 0-6, and, on the other hand, a corresponding number (i.e. the sequence on the same "level") in an adjoining column, the result will be the same independently of where along the two columns one makes the comparison. By means of the difference between two columns, it is thus possible to code an x-coordinate which is constant for all y-coordinates.

Since each position on the surface is coded with 4x4 symbols in this example, three differences (having the value 0-6) as stated above are available to code the x-coordinate. Then the coding is carried out in such manner that of the three differences, one will always have the value 1 or 2 and the other two will have values in the range 3-6. Consequently no differences are allowed to be zero in the x-code. In other words, the x-code is structured so that the differences will be as follows: (3-6) (3-6) (1-2) (3-6) (3-6) (1-2) (3-6) (3-6) (1-2)... Each x-coordinate thus is coded with two numbers between 3 and 6 and a subsequent number which is 1 or 2. If three is subtracted from the high numbers and one from the low, a number in mixed base will be obtained, which directly yields a position in the x-direction, from which the

x-coordinate can then be determined directly, as shown in the example below.

By means of the above described principle, it is thus possible to code x-coordinates 0,1,2..., with the aid of numbers representing three differences. These differences are coded with a bit pattern which is based on the number series above. The bit pattern can finally be coded graphically by means of the symbols in Fig. 2.

In many cases, when reading 4x4 symbols, it will not be possible to produce a complete number which codes the x-coordinate, but parts of two numbers. Since the least significant part of the numbers is always 1 or 2, a complete number, however, can easily be reconstructed.

The y-coordinates are coded according to the same principle as used for the x-coordinates. The cyclic number series is repeatedly written in horizontal rows across the surface which is to be position-coded. Just like in the case of the x-coordinates, the rows are allowed to begin in different positions, i.e. with different sequences, in the number series. However, for y-coordinates one does not use differences but codes the coordinates with numbers that are based on the starting position of the number series on each row. When the x-coordinate for 4x4 symbols has been determined, it is in fact possible to determine the starting positions in

number series for the rows that are included in the y-code in the 4x4 symbols. In the y-code the most significant digit is determined by letting this be the only one that has a value in a specific range. In this example, one lets one row of four begin in the position 0-1 in the number series to indicate that this row relates to the least significant digit in a y-coordinate, and the other three begin in the position 2-6. In y-direction, there is thus a series of numbers as follows: (2-6) (2-6) (2-6) (0-1) (2-6) (2-6) (2-6) (0-1) (2-6)... Each y-coordinate thus is coded with three numbers between 2 and 6 and a subsequent number between 0 and 1.

If 1 is subtracted from the low number and 2 from the high, one obtains in the same manner as for the x-direction a position in the y-direction in mixed base from which it is possible to directly determine the y-coordinate.

With the above method it is possible to code 4 x 4 x 2 = 32 positions in x-direction. Each such position corresponds to three differences, which gives 3 x 32 = 96 positions. Moreover, it is possible to code 5 x 5 x 5 x 2 = 250 positions in y-direction. Each such position corresponds to 4 rows, which gives 4 x 250 = 1000 positions. Altogether it is thus possible to code 96000 positions. Since the x-coding is based on diffe-

rences, it is, however, possible to select in which position the first number series begins. If one takes into consideration that this first number series can begin in seven different positions, it is possible to code 7 x 96000 = 672000 positions. The starting position of the first number series in the first column can be calculated when the x-coordinate has been determined. The above-mentioned seven different starting positions for the first series may code different sheets of paper or writing surfaces on a product.

With a view to further illustrating the invention according to this embodiment, here follows a specific example which is based on the described embodiment of the position code.

Fig. 3 shows an example of an image with 4x4 symbols which are read by a device for position determination.

These 4x4 symbols have the following values:

4 4 4 2

3 2 3 4

4 4 2 4

1 3 2 4

These values represent the following binary x- and y-code:

x-code:	y-code:
0 0 0 0	0 0 0 1
1 0 1 0	0 1 0 0
0 0 0 0	0 0 1 0
1 1 0 0	1 0 1 0

The vertical x-sequences code the following positions in the number series: 2 0 4 6. The differences between the columns will be -2 4 2, which modulo 7 gives: 5 4 2, which in mixed base codes position (5-3) x 8 + (4-3) x 2 + (2-1) = 16 + 2 +1 = 19. Since the first coded x-position is position 0, the difference which is in the range 1-2 and which is to be seen in the 4x4 symbols is the twentieth such difference. Since furthermore there are a total of three columns for each such difference and there is a starting column, the vertical sequence furthest to the right in the 4x4 x-code belongs to the 61st column in the x-code (3 x 20 + 1 = 61) and the one furthest to the left belongs to the 58th.

The horizontal y-sequences code the positions 0 4 1 3 in the number series. Since these series begin in the 58th column, the starting position of the rows are these numbers minus 57 modulo7, which yields the starting positions 6 3 0 2. Translated into digits in the mixed base, this will be 6-2, 3-2, 0-0, 2-2 = 4 1 0 0 where the third digit is the least significant digit in the number

at issue. The fourth digit is then the most significant digit in the next number. In this case, it must be the same as in the number at issue. (An exceptional case is when the number at issue consists of the highest possible digits in all positions. Then one knows that the beginning of the next number is one greater than the beginning of the number at issue.)

The position of the four-digit number will then in the mixed base be 0x50 + 4x10 + 1x2 + 0x1 = 42.

The third row in the y-code thus is the 43rd which has the starting position 0 or 1, and since there are four rows in all on each such row, the third row is number 43x4=172.

Thus, in this example, the position of the uppermost left corner for the 4x4 symbol group is (58,170).

Since the x-sequences in the 4x4 group begin on row 170, the x-columns of the entire pattern begin in the positions of the number series ((2 0 4 6) - 169) modulo 7 = 1 6 3 5. Between the last starting position (5) and the first starting position, the numbers 0-19 are coded in the mixed base, and by adding up the representations of the numbers 0-19 in the mixed base, one obtains the total difference between these columns. A naive algorithm to do so is to generate these twenty numbers and directly add up their digits. The resulting sum is called s. The

sheet of paper or writing surface will then be given by (5-s) modulo 7.

In the example above, an embodiment has been described, in which each position is coded with 4 x 4 symbols and a number series with 7 bits is used. Of course, this is but an example. Positions can be coded with a larger or smaller number of symbols. The number of symbols need not be the same in both directions. The number series can be of different length and need not be binary, but may be based on another base. Different number series can be used for coding in x-direction and coding in y-direction. The symbols can have different numbers of values.

In the example above, the marking is a dot but may, of course, have a different appearance. For example, it may consist of a dash which begins in the virtual raster point and extends therefrom to a predetermined position.

In the example above, the symbols within a square partial surface are used for coding a position. The partial surface may have a different form, such as hexagonal. The symbols need not be arranged in rows and columns at an angle of 90° to each other but can also be arranged in some other manner.

For the position code to be detected, the virtual raster must be determined. This can be carried out by

studying the distance between different markings. The shortest distance between two markings must derive from two neighboring symbols having the value 1 and 3 so that the markings are located on the same raster line between two raster points. When such a pair of markings has been detected, the associated raster points can be determined with knowledge of the distance between the raster points and the displacement of the markings from the raster points. When two raster points have once been located, additional raster points can be determined by means of measured distances to other markings and with knowledge of the relative distance of the raster points.

An embodiment of a device for position determination is schematically shown in Fig. 4. The device comprises a casing 11 having approximately the shape of a pen. In one short side of the casing there is an opening 12. The short side is intended to abut against or be placed a short distance from the surface on which the position determination is to be carried out.

The casing contains essentially an optics part, an electronic circuitry part, and a power supply.

The optics part comprises at least one light emitting diode 13 for illuminating the surface which is to be imaged and a light-sensitive area sensor 14, such as

a CCD or CMOS sensor, for recording a two-dimensional image. The device may also comprise a lens system.

The power supply to the device is obtained from a battery 15 which is mounted in a separate compartment in the casing.

The electronic circuitry part comprises image processing means 16 for determining a position on the basis of the image recorded by the sensor 14 and more specifically a processor unit with a processor which is programmed to read images from the sensor and to carry out position determination on the basis of these images.

In this embodiment, the device also comprises a pen point 17, with the aid of which is possible to write ordinary pigment-based writing on the surface upon which the position determination is to be carried out. The pen point 17 is extendable and retractable so that the user can control whether or not it is to be used. In certain applications, the device need not have a pen point at all.

Moreover, the device comprises buttons 18 by means of which the user activates and controls the device. It also comprises a transceiver 19 for wireless transfer, e.g. using IR light or radio waves, of information to and from the device. The device can also comprise a display 20 for showing positions or recorded information.

Applicant's Swedish Patent No. 9604008-4 describes a device for recording text. This device can be used for position determination if programmed in a suitable way. If it is to be used for pigment-based writing, it must also have a pen point.

The device can be divided into different physical casings, a first casing containing components required for capturing images of the position-coding pattern and for transferring them to components which are located in a second casing and which carry out the position determination on the basis of the recorded image or images.

As mentioned above, the position determination is carried out by a processor which thus must have software to locate and decode the symbols in an image and to determine positions on the basis of the thus obtained codes. A person skilled in the art can, starting from the example above, design software which carries out position determination on the basis of an image of part of a position-coding pattern.

Moreover, the skilled person can design, on the basis of the above description, software for printing the position-coding pattern.

In the above embodiment, the pattern is optically readable and, accordingly, the sensor is optical. As mentioned above, the pattern can be based on a parameter

other than an optical parameter. Obviously, in that case the sensor must be of a type which can read the parameter in question.

In the above embodiment, the raster is a checked network. It can also have other forms.

In the above embodiment, the longest possible cyclic number series is not used. Thus, a certain amount of redundancy is provided which can be used, for example, to check the turning of the read group of symbols.

What we claim and desire to secure by Letters Patent is:

1. A product which has a surface (2) provided with a coding pattern (3) which comprises symbols (4) representing at least two different values, c h a r a c - t e r i z e d in that each symbol comprises a raster point (5) and at least one marking (6); the raster point is included in a raster which extends across the surface; and the value of each symbol is indicated by the position of said marking in relation to a raster point.

2. A product as claimed in claim 1, wherein essentially all markings (6) in the coding pattern are identical.

3. A product as claimed in claim 1 or 2, wherein the coding pattern is a position-coding pattern which codes a plurality of positions on the surface, each position being coded by a plurality of symbols.

4. A product as claimed in claim 3, wherein each symbol (4) contributes to the coding of more than one of said plurality of positions.

5. A product as claimed in claim 3 or 4, wherein said symbol (4) contributes to the coding of both a first and a second position coordinate.

6. A product as claimed in claim 5, wherein the value of each symbol is translatable into at least a

(continued)

(continued claim 6)

first digit which is used to code the first position coordinate and at least a second digit which is used to code the second position coordinate, the symbols in the position-coding pattern together representing a first position code for the first position coordinate and a second position code for the second position coordinate.

7. A product as claimed in any one of claims 3-7, wherein the position-coding pattern (3) is based on a first cyclic number series which has the characteristic that no sequence with a first predetermined number of digits appears more than once in the number series.

8. A product as claimed in claim 4, wherein the first coordinate is coded by a first cyclic number series, which has the characteristic that no sequence with a first predetermined number of digits appears more than once in the number series, being repeated in columns across the surface, the columns beginning in different positions in the number series.

9. A product as claimed in claim 8, wherein the second coordinate is coded by a second cyclic number series, which has the characteristic that no sequence with a second predetermined number of digits appears more than once in the number series, being repeated in rows

(continued)

(continued claim 9)

across the surface, the rows beginning in different positions in the number series.

10. A product as claimed in claim 9, wherein the product (1) comprises a plurality of writing surfaces each comprising the position-coding pattern, the position-coding patterns differing for the different writing surfaces by the sequence in the cyclic number series with which a predetermined column or row begins.

11. A product as claimed in any one of the preceding claims, wherein said raster and said raster point are virtual.

12. A product as claimed in any one of the preceding claims, wherein each symbol has exactly one marking which can be placed in one of four predetermined positions on the lines of the raster, so that the symbol has exactly four values.

13. A product as claimed in any one of the preceding claims, wherein the coding pattern is optically readable.

14. A product having a surface (2) which is provided with a position-coding pattern (3) coding a plurality of positions on the surface, and which has a plurality of symbols (4), each symbol having at least four different values, c h a r a c t e r i z e d in that each position

(continued)

(continued claim 14)

on the surface is coded with a plurality of symbols, and that the value of each symbol is translatable into at least a first digit which is used to code a first coordinate and at least a second digit which is used to code a second coordinate, the symbols in the position-coding pattern together representing a first position code for the first coordinate and a second position code for the second coordinate.

15. A product as claimed in claim 14, wherein the first and the second position code are a binary position code.

16. A product as claimed in claim 14 or 15, wherein each of said symbols contributes to the coding of more than one of said plurality of positions so that adjoining positions are coded partially with the same symbols.

17. A method of creating a position-coding pattern, which is designed for coding a plurality of positions on a surface, comprising the steps of

generating a first cyclic number series having the characteristic that no sequence with a first predetermined number of digits appears more than once in the number series;

coding a first coordinate by repeating the first cyclic binary number series in columns across the

(continued)

(continued claim 17)

surface, different columns beginning in different positions in the number series;

generating a second cyclic number series having the characteristic that no sequence with a first predetermined number of digits appears more than once in the number series; and

coding a second coodinate by repeating the second cyclic number series in rows across the surface, different rows beginning in different positions in the number series.

18. A method as claimed in claim 17, wherein the first and the second number series are binary.

19. A method as claimed in claim 17 or 18, wherein the coding of one of the first coordinate and the second coordinate is based on a position displacement between adjoining columns or rows; and the coding of the other of the first coordinate and the second coordinate is based on the positions in the number series at the beginning of the rows or columns.

20. A computer program stored on a computer-readable storage medium which comprises instructions for making a computer decode the position-coding pattern on a product according to any one of claims 1-16.

21. A computer program for determining the position of a partial surface on a surface which is provided with a position-coding pattern comprising a plurality of symbols, on the basis of an image of the partial surface, said computer program being stored on a computer-readable storage medium which comprises instructions for making the computer

locate a predetermined plurality of symbols in the image;

determine the value of each of said predetermined plurality of symbols;

separate the position-coding pattern in the image in a first position code for a first coordinate for the partial surface and a second position code for a second coordinate for the partial surface by translating the value of each symbol into at least a first digit for the first position code and at least a second digit for the second position code; and

calculate the first coordinate by means of the first position code and the second coordinate by means of the second position code.

22. A computer program as claimed in claim 21, wherein each symbol comprises a raster point and at least one marking and wherein the value of each symbol is

(continued)

(continued claim 22)

determined by determining the position of each marking in relation to the raster point.

23. A device for position determination, comprising a sensor (14) for producing an image of a partial surface on a surface and image processing means (16), which are adapted to decode a position-coding pattern on a product as claimed in any one of claims 1-16, said surface being a surface on the product, which surface is provided with the position-coding pattern.

24. A device for position determination, comprising a sensor (14) for producing an image of one partial surface of a plurality of partial surfaces on a surface which is provided with a position-coding pattern, and image processing means (16) which are adapted to

locate a predetermined plurality of symbols in the image;

determine the value of each of said predetermined plurality of symbols;

separate the position-coding pattern in the image in a first position code for a first coordinate for the partial surface and a second position code for a second coordinate for the partial surface by translating the value of each symbol into at least a first digit for the

(continued)

(continued claim 24)

first position code and at least a second digit for the second position code; and

calculate the first coordinate by means of the first position code and the second coordinate by means of the second position code.

25. A device as claimed in claim 24, wherein the device is hand-held.

26. A device as claimed in claim 24 or 25, wherein the device has means (19) for wireless transfer of position information.

27. Use of a position-coding pattern, which position-coding pattern is based on a first cyclic number series having the characteristic that no sequence with a first predetermined number of digits appears more than once in the number series; the first cyclic number series being repeated in columns across the writing surface, different columns beginning in different positions in the number series, and on a second cyclic number series having the characteristic that no sequence with a second predetermined number of digits appears more than once in the number series, the second cyclic number series being repeated in rows across the writing surface, different rows beginning in different positions in the number series.

Abstract of the Disclosure

A product has a surface provided with a position-coding pattern (3) which codes a plurality of positions on the surface. The position-coding pattern comprises a plurality of symbols (4), each having at least two different values. Each position on the surface is coded with a plurality of symbols. Each symbol comprises a raster point (6) which is included in a raster extending across the surface, and at least one marking (7), the position of which in relation to the raster point indicates the value of the symbol.

The position-coding pattern can be used in various situations for position determination, for instance in digitization of handwritten text.

Elected for publication: Figs 2a-d

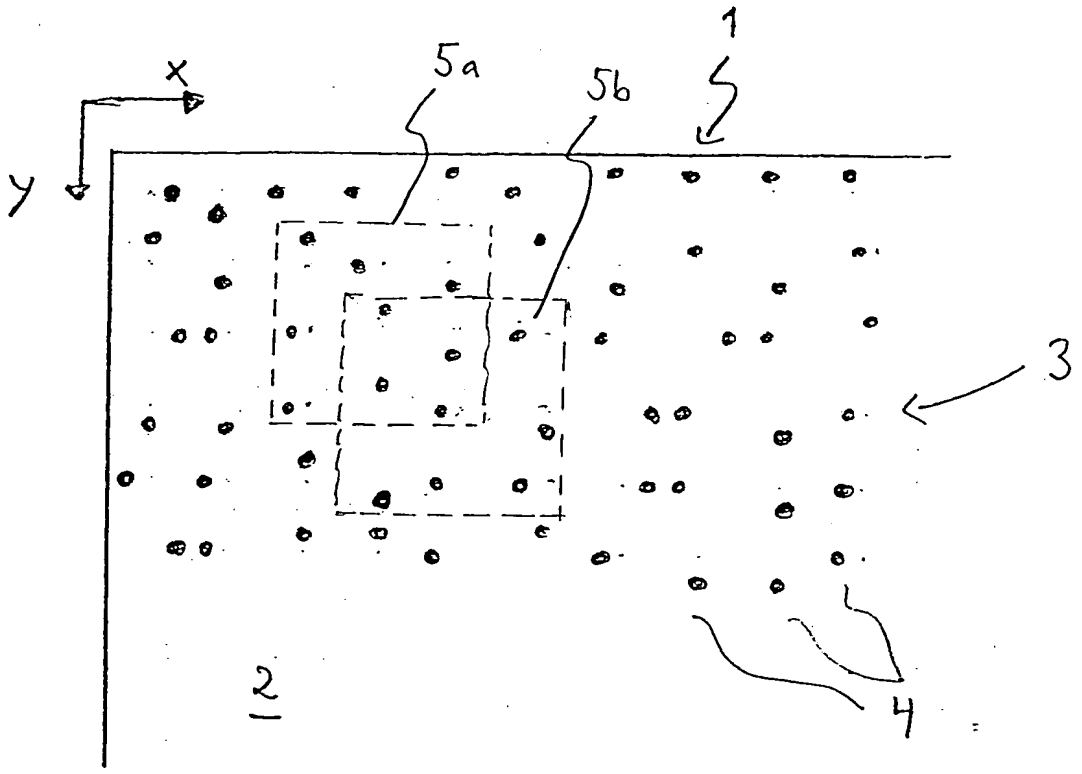

Fig 1

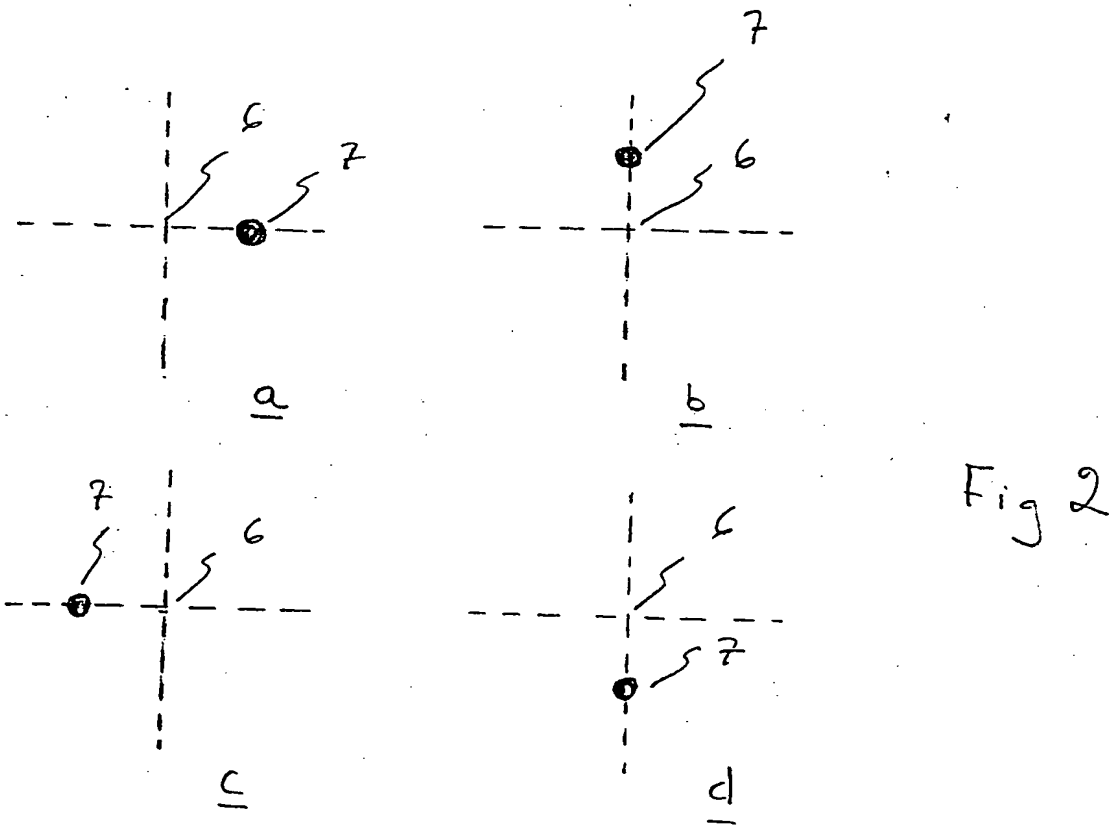

Fig 2

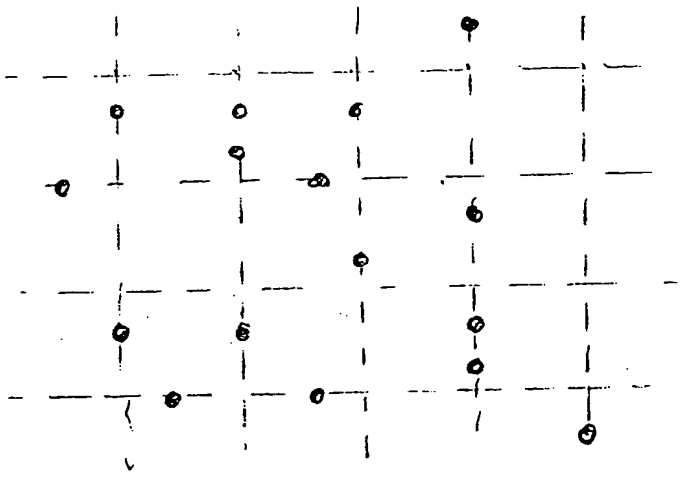

Fig 3

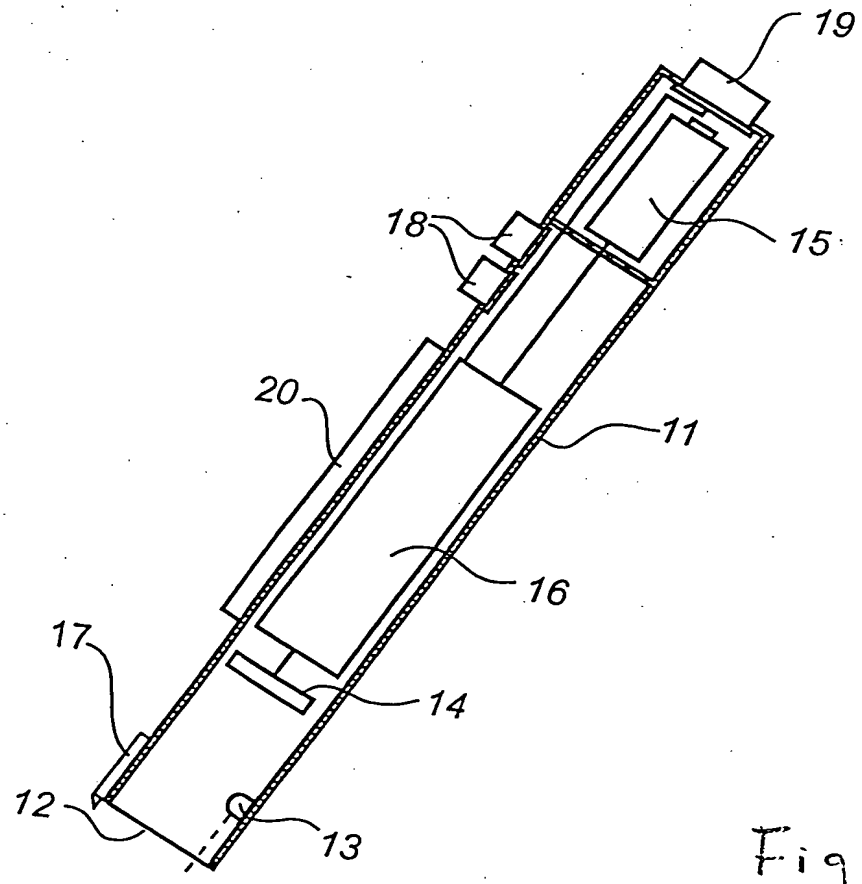

Fig 4